Title:	**Using Auxin Treatments to improve Pinyon Pine Transplant Survival**
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FINAL STATUS OF THE PROJECT

Materials and Methods:

The experiment, growing pinyon pine seedlings in a gravel bed, field soil or container medium after seedlings received an auxin treatment, was started on April 8, 2005. A gravel bed measuring 10 ft. by 12 ft. by 1.2 ft. was filled with a mixture of 60% pea gravel (3/8-inch minus), 30% Turface®, and 10% silica sand (by volume). A field bed 10 ft. by 12 ft. in size was also prepared by tilling the soil 60 cm deep, adding 20 ft^3 of Eko compost, and tilling in the compost to a depth of 25 cm. Pinyon pine (*Pinus edulis*) 3-0 seedlings were received three days before planting and held in refrigerated storage until planting in the gravel bed and containers (April 8). The containers used in this study were plastic C-900 pots (tall 2-gallon size). The remaining pine seedlings were planted in the field bed on April 27 after the soil dried sufficiently to complete bed preparation. Before planting the seedlings, they were randomly assigned to receive an auxin treatment. Seedlings were treated with 0 (distilled water control), 1,000, 2,000, or 4,000 $mg \cdot L^{-1}$ of potassium salt of indole-3-butyric acid (K-IBA). Six plants received one auxin treatment per block, and four blocks were used for each type of growth medium (gravel, field soil, or potting mix). Treatments were randomly assigned to rows in each block to provide a randomized complete block design. Therefore, a total of 96 plants were used in each type of growth medium. Extra seedlings were used as guard rows to separate the blocks of experimental seedlings.

The container medium consisted of 74% aged pine bark, 13% peat moss, 6.5% silica sand, and 6.5% Eko compost (by volume). Scott's Osmocote® 15-9-12 at a rate of 8 lbs. per cubic yard was incorporated into the potting mix before planting. The pH and electrical conductivity (EC) of the mix were 6.75 and 1.69 $dS \cdot m^{-1}$, respectively. The air-filled porosity, water-holding capacity, and total porosity of the potting mix was 28.2%, 45.8%, and 74%, respectively. The gravel bed and field soil were not fertilized.

The experiment ended on October 13, which was about 27 weeks after beginning the study. Pinyon pine seedlings were carefully dug out of the gravel bed. Container seedlings that had green foliage were carefully removed from the potting mix. All seedlings planted in the field bed were dead. If seedlings had roots on them, their increase in new height growth was measured along with average stem diameter and root volume. Average stem diameter was determined by measuring stem diameter, turning the seedling 90 degrees and then making a second measurement. Average stem diameter was the average of the two measurements. Root volume was also recorded by measuring the volume of water the roots displaced in a graduated cylinder. The number of seedlings that survived at the end of the first growing season was also counted. Finally, seedlings were cut into two pieces at the root-stem union, and the shoots and roots were placed in different paper bags for drying. Root and shoot dry weights were determined by drying roots and shoots for at least 3 days at 70°C.

Statistical analyses of the data included using categorical modeling and analysis of variance. The number of seedlings that survived only for gravel bed plants was analyzed by using a categorical modeling analysis (Proc GENMOD in SAS). This test was used to determine if any of the IBA concentrations promoted or inhibited transplant survival. A single degree-of-freedom contrast was also completed to determine if the auxin treatments considered together improved seedling survival compared to control seedlings. Analysis of variance was used to determine if the auxin treatments affected mean stem diameter, seedling height growth, root volume, shoot dry weight or root dry weight. The overall probability needed to show significant treatment effects had to be at or below the 5% level ($P \leq 0.05$) when completing the various statistical analyses.

Results:

Pinyon pine again showed that it was a difficult species to transplant. A total of 96 seedlings were planted in each medium (gravel bed, field soil and pine bark mix). Any seedling that had green foliage and produced new roots was considered to have survived the growing season. Seedlings planted in the gravel bed survived the best, but only 28% (27 out of 96 plants) survived. Only one seedling planted in containers survived, and all seedlings planted in the field bed died. For the gravel bed seedlings, four out of 24 seedlings whose roots were treated with distilled water (control) survived, whereas of the 24 seedlings treated with either 1,000, 2,000, or 4,000 $mg \cdot L^{-1}$ K-IBA, eight, four, and eleven seedlings, respectively, survived. The statistical analysis of the survival rates revealed that the auxin treatments failed to improve seedling survival in the gravel beds ($P>0.067$). The single degree-of-freedom contrast that tested the survival percentages of control seedlings versus the percentages of all auxin seedlings combined also showed that the IBA treatments failed to promote or inhibit seedling survival in the gravel beds ($P>0.179$).

The auxin treatments failed to influence the growth of seedlings in the gravel bed. For all gravel bed seedlings, regardless of the auxin treatment applied, new height growth of their main leaders averaged 1.0 cm ($P>0.176$), and their stem diameters averaged 6.2 mm ($P>0.282$). Shoot dry weight for all gravel bed seedlings was 10.6 g ($P>0.450$). The mean root dry weight of these seedlings was 2.5 g ($P>0.532$), and the mean root volume was 6.1 cm^3 ($P>0.441$). Comparisons of growth parameters of seedlings grown in gravel versus the field or containers were not completed due to low survival rates in the other two media (pine bark mix or soil).

Discussion:

The pinyon pine seedlings planted in the gravel bed survived best compared to those planted in the field or in a pine bark potting mix. One surprise from this study was that most of the seedlings planted in containers died with only one seedling out of 96 surviving and producing roots. The potting mix was well aerated (28.2% air-filled porosity) and should have supported the growth of the seedlings. In addition, the potting mix was watered as frequently and received as much water as the gravel bed. Perhaps the potting mix still held too much water for the pinyon pine seedlings to survive. Alternatively, the root temperatures of seedlings in containers were most likely hotter than those of plants in the gravel bed. Perhaps the elevated root temperatures negatively affected root regeneration and ultimately survival of the pine seedlings.

The auxin treatments failed to affect seedling growth and survival in the different growth media (gravel, soil, or pine bark mix). We were surprised that the auxin, indole-3-butyric acid, neither promoted nor inhibited plant growth or survival. Although almost three-fold more seedlings treated with the highest concentration of IBA (4,000 $mg{\bullet}L^{-1}$) survived compared to control seedlings (treated with distilled water), the auxin treatments failed to have an effect on overall survival of the seedlings planted in gravel ($P>0.067$). Therefore, using IBA on the pinyon pine seedlings' root systems was unneeded for seedling growth and survival in the gravel bed or the containers or soil for that matter.

Pinyon pine seedlings continue to demonstrate that they are difficult to transplant. The best transplant medium so far has proven to be a gravel bed, perhaps because of its good aeration and cool root environment. Root regeneration seems difficult for pinyon pine seedlings, so any treatment that can reduce stress should improve transplant survival. The results from the container part of this study were disappointing, since the container medium seemed well aerated. Perhaps it still held too much water for the pinyon pine seedlings, and the medium got too hot under summer growing conditions. Transplanting pinyon pine seedlings directly to field soil once they have been removed from the seedling bed continues to be a problem. Perhaps reducing stress of seedlings will help them to survive transplanting into soil

Significance to the Nursery Industry:

This study demonstrated that seedlings of pinyon pine, a difficult-to-transplant species, can be grown in a gravel bed to regenerate root systems and survive the first year after being dug from the seed bed. The results from this study were similar to those of the 2004 experiment. Even though the seedlings survived almost exclusively in the gravel bed, the percentage of survival was still low (28%) and perhaps commercially nonviable. Pinyon pine is a highly desirable native conifer for the landscape trade, but until nursery cultural practices can be adjusted to help this species survive and even thrive after it is dug from the seed bed, it will be avoided by nurseries. This species is adapted to dry landscapes, so perhaps adjusting cultural practices to reduce plant stress during the first year after digging seedlings from seed bed will improve plant survival. Reducing stress can be done in several ways, including shading the seedlings transplanted into a gravel bed or field soil. Since a gravel bed is a non-conventional growth medium, being able to transplant pinyon pine seedlings into containers should also improve the chances of this species being produced by nurseries. In this study, pinyon pine seedlings failed to grow in plastic pots. Perhaps instead fabric pots can be used to provide enough aeration and maintain lower root temperatures to enhance root regeneration and survival of transplanted seedlings. I have submitted two proposals to test these potential improvements for pinyon pine survival.